GUIDE FOR EVALUATING BLAST RESISTANCE

OF

NONSTANDARD MAGAZINES

PREPARED BY

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FOREWARD

The information in this guide is the result of full and reduced scale tests that were made in order to determine the explosive effects resulting from an explosion in an earth-covered magazine. The guide also represents the application of the structural analyses methods given in TM 5-1300, "Structures to Resist the Effects of Accidental Explosions," in order to develop procedures that can be used to determine the adequacy of existing nonstandard magazine headwalls and doors to withstand the effects from an explosion in an adjacent magazine. This guide should not be used for establishing the requirements for new magazine designs.

Comments concerning corrections or improvements are invited.

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1.0 INTRODUCTION

1.1 Purpose.

The purpose of this guide is to provide installations with procedures to determine the adequacy of nonstandard magazine headwalls to withstand the blast from a known quantity of explosives at a known distance. This is accomplished by comparing the impulse capacities of the various headwall elements (wall, pilaster, and door) to the impulse generated by an imposed blast environment. The impulse capacities for the various headwall elements and the blast environment data are supplied by this guide. The guide may also be used to determine the amount of explosives stored in an acceptor magazine from an incident in an adjacent magazine (donor magazine). A nonstandard magazine is any magazine not listed as standard in paragraph B.1., Chapter 5 of DoD 6055.9-STD. This guide should not be used for establishing the requirements for new magazine designs.

In order for the results of the analysis made by using this guide to be considered reliable, it is important that the structural values (i.e., wall or door thicknesses and percent steel in the walls or pilasters) used in the analysis accurately reflect the as-built conditions. For this reason, the guide should only be used with data taken from as-built drawings or from field measurements. If as-built drawings are not available for determining the percentage of steel in the concrete portions (wall and pilaster) of the headwall, then the default values given in paragraph 1.5 can be used.

1.2 Scope of Guide.

This guide is applicable to the analysis of headwalls for magazines having an inside radius of approximately 13 feet. The magazine arch may consist of either corrugated steel or reinforced concrete. This guide is applicable to headwalls with or without thickened wall sections (pilasters) at the door. The wall and pilaster rotations are limited to a maximum of 12 degrees for the indicated wall impulse capacities. At this rotation, the wall or pilaster will approach an imminent collapse but detonation of stored explosives is not expected. The door rotations are also limited to a maximum of 12 degrees for the indicated door impulse capacities. At this rotation, the door will experience a large plastic deflection but will not fail and subject the magazine contents to blast effects that could lead to propagation. It is assumed that the magazines are arranged in parallel rows with all magazines facing the same direction.

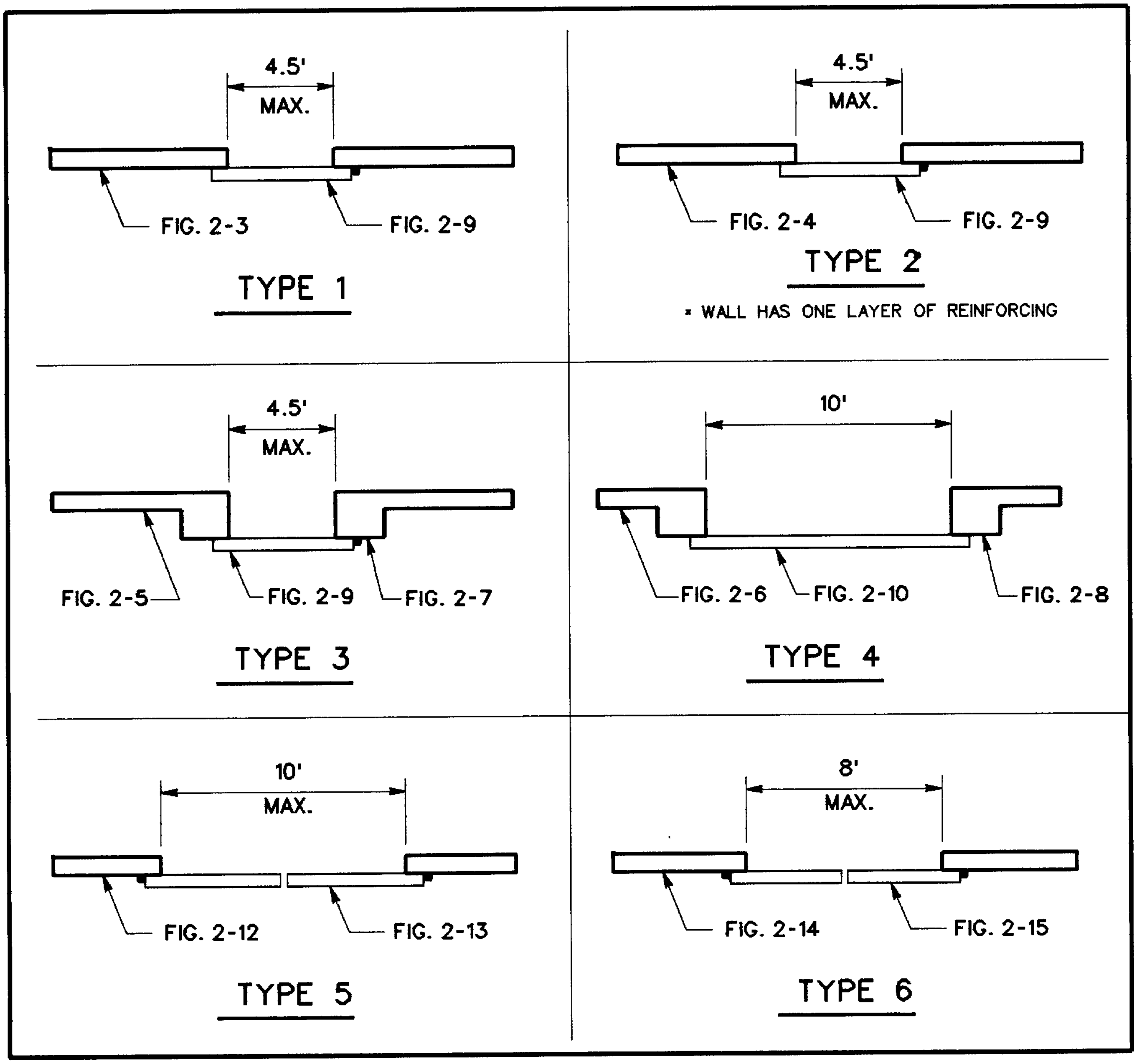

Figure 1-1 Headwall Configuration Types (Plan View)

1.3 Types of Headwall Configurations.

As shown in Figure 1-1, the magazine headwall combinations that are covered by this guide are divided into six types which are described as follows:

a. Type 1 Headwall Configuration

(1) Wall. The wall for the Type 1 configuration consists of a wall with equal amounts of reinforcing in each direction at each face. The wall opening for the single-leaf door has a maximum clear height of 8 feet and a maximum clear width of 4.5 feet. The wall impulse curves are valid for walls with smaller door openings but not larger openings.

(2) Door. The door for the Type 1 configuration is a single-leaf door consisting of an unstiffened single-thickness plate with variations in door sill support conditions. The clear opening for the door has a maximum height of 8 feet and a maximum width of 4.5 feet. The door impulse curves are valid for doors that cover smaller wall openings but not larger openings.

b. Type 2 Headwall Configuration

(1) Wall. The wall for the Type 2 configuration consists of a wall with equal amounts of reinforcing in each direction at the centerline of the wall. The wall opening for the single-leaf door has a maximum clear height of 8 feet and a maximum clear width of 4.5 feet. The wall impulse curves are valid for walls with smaller door openings but not larger openings.

(2) Door. The door for the Type 2 configuration is a single-leaf door consisting of an unstiffened single-thickness plate with variations in door sill support conditions. The clear opening for the door has a maximum height of 8 feet and a maximum width of 4.5 feet. The door impulse curves are valid for doors that cover smaller wall openings but not larger openings.

c. Type 3 Headwall Configuration

(1) Wall. The wall for the Type 3 configuration consists of a wall with equal amounts of reinforcing in direction at each face. The opening for the single-leaf door has a maximum clear height of 8 feet and a maximum clear width of 4.5 feet. The wall impulse curves are not valid for any other size door openings.

(2) Pilaster. The pilaster for the Type 3 configuration has equal amounts of vertical steel bars at each

face. The pilaster impulse curves are valid for pilasters with smaller door openings but not larger openings.

(3) Door. The door for the Type 3 configuration is a single-leaf door consisting of an unstiffened single-thickness plate with variations in door sill support conditions. The clear opening for the door has a maximum height of 8 feet and a maximum width of 4.5 feet. The door impulse curves are valid for doors that cover smaller openings but not larger openings.

d. Type 4 Headwall Configuration

(1) Wall. The wall for the Type 4 configuration consists of a wall with equal amounts of reinforcing in each direction at each face. The clear opening for the door is 10 feet in both height and width. The wall impulse curves are not valid for larger size door opening, but can be conservatively used for smaller doors.

(2) Pilaster. The pilaster for the Type 4 configuration has equal amounts of vertical steel bars at each face. The pilaster impulse curves are valid for pilasters with smaller door openings but not larger openings.

(3) Door. The door for the Type 4 configuration consists of a single-unit steel door that has support at each door jamb. Any support provided at the top of the door has conservatively not been considered. The door structure consists of interior and exterior steel face plates welded to standard structural shapes spanning in the horizontal direction. These structural shapes must span in the horizontal direction in order for the analysis procedures to be valid. The clear opening for the door is 10 feet in both height and width. The door impulse curves are valid for smaller door sizes but not larger sizes.

e. Type 5 Headwall Configuration

(1) Wall. The wall for the Type 5 configuration consists of a wall with equal amounts of reinforcing in each direction at each face. The wall opening for the double-leaf door has a maximum clear height of 10 feet and a maximum clear width of 10 feet. The wall impulse curves are valid for walls with smaller door openings but not larger openings.

(2) Door. The door for the Type 5 configuration consists of stiffened double-leaf steel doors that are continuously supported at the head and hinge jamb and with either a continuous support at the sill or with a 1.375" diameter sill latch pin on each leaf with no continuous sill support. The door structure consists of interior and exterior steel plates separated by spacer bars. The clear opening for the double door is 10 feet in both height and width. The door

impulse curves and valid for smaller door sizes but not larger sizes.

f. Type 6 Headwall Configuration

(1) Wall. The wall for the Type 6 configuration consists of a wall with equal amounts of reinforcing in each direction at each face. The wall opening for the double-leaf door has a maximum clear height of 8 feet and a maximum clear width of 8 feet. The wall impulse curves are valid for walls with smaller door openings but not larger openings.

(2) Door. The door for the Type 6 configuration consists of stiffened double-leaf steel doors that are continuously supported at the head and hinge jamb and with either a continuous support at the sill or with a 1.3125" diameter sill latch pin on each leaf with no continuous sill support. The door structure consists of interior and exterior steel plates separated by spacer bars. The clear opening for the double door is 8 feet in both height and width. The door impulse curves are valid for smaller door sizes but not larger sizes.

1.4 Format for Guide.

The guide is presented as a set of 15 figures as follows:

a. Blast Loadings. Figures 2-1 and 2-2 provide the scaled incident and reflected impulses respectively, resulting from an explosive detonation in an adjacent magazine. All scaled impulses represent those at the exterior face of the acceptor magazine. The scaled impulses represent the upper range of field measurements taken during full and reduced scale explosive tests. The scaled impulses resulting from an unconfined surface explosion are also provided.

(1) Figure 2-1 presents the scaled incident impulse resulting from an explosion originating inside of a magazine located to the side of and parallel to the acceptor magazine. The incident impulse is plotted as a function of the side to side scaled distance between the magazines. The scaled distance for Figure 2-1 is conservatively taken as the clear distance between the sides of the parallel magazine arches.

(2) Figure 2-2 presents the scaled reflected impulse resulting from an explosion originating inside of a magazine located to the front of and facing in the same direction as the acceptor magazine. The reflected impulse is plotted as a function of the scaled back to front distance between the magazines. The scaled distance for Figure 2-2 is conservatively taken as the distance between the rear wall of the donor magazine to the front wall of the acceptor magazine.

b. Wall Capacities. Figures 2-3 through 2-6 and 2-12 through 2-14 provide the wall impulse capacities for the acceptor magazine. The impulse capacities were determined by analyzing various wall configurations using the procedures given in TM 5-1300, "Structures to Resist the Effects of Accidental Explosions." The wall configurations represent those that might be found in many of the nonstandard magazines. The figures present the wall impulse capacity as a function of percent of wall reinforcing steel for various wall thicknesses. The percent steel should be calculated using the gross section of the wall.

(1) Figures 2-3, 2-4, 2-12, and 2-14 provide the wall impulse capacities for walls without a thickened wall section (pilaster) at the door jambs.

(2) Figures 2-5 and 2-6 provide the wall impulse capacities for walls with a thickened wall section (pilaster) at the door jambs.

c. Pilaster Capacities. Figures 2-7 and 2-8 provide the pilaster impulse capacities for the acceptor magazine. The impulse capacities were determined by analyzing various door configurations using the procedures given in TM 5-1300, "Structures to Resist the Effects of Accidental Explosions."
The pilaster configurations represent those that might be found in many of the nonstandard magazines. The figures present the pilaster impulse capacity per foot of pilaster width as a function of percent of pilaster vertical reinforcing steel for various pilaster thicknesses. The percent steel should be calculated using the gross section of the pilaster.

d. Door Capacities. Figures 2-9, 2-10, 2-13, and 2-15 provide the magazine door impulse capacities for the acceptor magazine. The impulse capacities were determined by analyzing various door configurations using procedures given in TM 5-1300, "Structures to Resist the Effects of Accidental Explosions." The door configurations represent those that might be found in many of the nonstandard magazines.

(1) Figure 2-9 provides the door impulse capacity for an unstiffened single-leaf door with or without edge support at the door sill. The door impulse capacity is plotted as a function of door plate thickness.

(2) Figure 2-10 provides the door impulse capacity for a stiffened single-unit steel door for various door thicknesses. The door capacity is plotted as a function of the door strength value V. The value of V is determined by the equations presented in Figure 2-11.

(3) Figure 2-13 provides the door impulse capacity for a stiffened double-leaf steel door for various door

thicknesses. The door capacity is plotted as a function of the door strength value V. The value of V is determined by the equations presented in Figure 2-11.

(4) Figure 2-15 provides the door impulse capacity for a stiffened double-leaf steel door for various door thicknesses. The door capacity is plotted as a function of

the door strength value V. The value of V is determined by the equations presented in Figure 2-11.

1.5 Default Values for Wall and Pilaster Percent Steel.

In the absence of as-built drawings that provide information from which the percentages of steel can be determined for the walls and pilasters, the values shown below can be used. These values are based on minimum requirements for wall and beam (pilaster) percent steel as historically required by the American Concrete Institute.

For all walls (with or without pilasters):

- o Use percent steel (each way, each face) = 0.12

- o Use Figure 2-4 for all walls.*

For all pilasters:

- o Use percent vertical steel (each face) = 0.50**

- o Use Figures 2-7 or 2-8.

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* When using assumed percentage of steel for the wall, Figure 2-4 must be used for determining the wall impulse capacity for all wall configurations (i.e. Figure 2-4 must be used in place of Figures 2-3, 2-5, 2-6. 2-12, and 2-14.)

** (0.50 percent = [(200/f_y)(100)]=[(200/40,000)(100)], from old ACI codes that were in effect when magazines were built.)

2.0 ANALYSIS PROCEDURES

2.1 General.

The procedures listed below were developed for the purpose of evaluating the blast resistance of nonstandard ammunition storage magazines or for determining the amount of explosives that may be stored in an adjacent magazine without creating a blast propagation hazard to an adjacent nonstandard magazine.

a. Procedure 1 - Evaluate Blast Resistance of Nonstandard Magazine. The procedure involves a series of sequential steps which are applicable to the Type 1 through Type 6 Headwall Configurations shown in Figure 1-1. The number of steps will vary depending on the headwall configuration being analyzed.
The basic procedure is as follows:

(1) Determine the impulse loading on the acceptor magazine from Figure 2-1 and/or Figure 2-2.

(2) Determine the impulse capacity for each of the applicable magazine elements (wall, pilaster, and door) from Figure 2-3 through Figure 2-15 and compare each capacity to the impulse loading.

The type 4 Headwall Configuration will be used to illustrate Procedure 1. Since the type 4 Configuration is composed of three structural elements (wall, pilaster, and door), it will be necessary to analyze each of these three elements to determine if any one fails to provide the required resisting impulse capacity. A similar but shorter procedure can be used for the Types 1 and 2 headwall configurations because a pilaster analysis is not required. Since the door for the Type 4 Configuration consists of a stiffened plate structure, the analysis procedure will be more involved because of the requirement to determine the door strength value (V). The procedure for determining the door impulse capacity for Types 1, 2, and 3 configurations is less involved because only the door thickness is required to determine the door impulse capacity.

b. Procedure 2 - Determine Allowable Quantity of Stored Explosive. Procedure 2 is similar to Procedure 1 except in reverse order and involves a trial and error process for determining the allowable quantity of stored explosive. The basic procedure is as follows:

(1) Determine the smallest impulse capacity of the applicable magazine elements (wall, pilaster, and door) from Figures 2-3 through 2-10.

(2) Select a value for the allowable quantity of stored explosive. In selecting a quantity of stored explosive,

there is no need to select a quantity less than 250,000 pounds because paragraph B.2, Chapter 5 of DOD 6055.9-STD, "DOD Ammunition and Explosives Safety Standards," dated October 1992, states that all nonstandard earth-covered magazines are "approved for all quantities of explosives up to 250,000 pounds" of net explosive weight. The latest edition of this standard should be checked for any changes to this allowable quantity of store explosive.

(3) Determine the impulse loading on the acceptor magazine from Figure 2-1 and/or Figure 2-2 and compare to the impulse capacity previously determined.

(4) Adjust the value for the allowable quantity of stored explosive as necessary and repeat Step 3.

2.2 Procedure 1 - Evaluate Blast Resistance of Nonstandard Magazine.

STEP 1: From Figure 1-1, select the headwall configuration type that most closely matches the existing magazine. The configuration type will determine the figures to be used in the analysis. For this example, Headwall Configuration Type 4 will be used.

STEP 2: Determine the net explosive weight (W) in pounds of the explosive material stored in the donor magazine.

STEP 3: For the condition with the donor magazine located to the side of the acceptor magazine, determine the clear distance in feet (R) between the sides of the magazine arches (see Figure 2-1).

STEP 4: Calculate the scaled distance by dividing the distance (R) in Stem 3 by the cube root of the net explosive weight (W) determined in Step 2.

STEP 5: Enter Figure 2-1 with the scaled distance $R/W^{1/3}$ from Step 4 and read the value of the scaled incident impulse $Is/W^{1/3}$ from the solid lined curve for a confined explosion.

STEP 6: Calculate the incident impulse (Is) by multiplying the scaled incident impulse value from Step 5 by $W^{1/3}$.

STEP 7: If there is no magazine in front of the acceptor magazine, then steps 7 through 10 will not be necessary. For the

condition with a donor magazine located in front of the acceptor magazine, determine the clear distance in feet (R) between the rear wall of the donor magazine and the front (head) wall of the acceptor magazine (see Figure 2-2).

STEP 8: Calculate the scaled distance by dividing the distance (R) in Step 7 by the cube root of the net explosive weight (W) determined in Step 2.

STEP 9: Enter Figure 2-2 with the scaled distance $R/W^{1/3}$ from Step 8 and read the value of the scaled reflected impulse $Ir/W^{1/3}$ from the solid line curve for a confined explosion.

STEP 10: Calculate the reflected impulse (Ir) by multiplying the scaled reflected impulse value from Step 9 by $W^{1/3}$.

STEP 11: Select the larger of the values from Step 6 and Step 10 (only one value from Step 6 will exist if there is no donor magazine in front of the acceptor magazine.)

STEP 12: From Figure 2-6, determine the wall impulse capacity (Iw).

STEP 13: From Figure 2-8, determine the pilaster impulse capacity (Ip). Note that the values presented in Figure 2-8 must be multiplied by the pilaster width in feet in order to obtain the total pilaster impulse capacity.

STEP 14: From Figure 2-10, determine the door impulse capacity (Id). The door strength value (V) is determined by the information given in Figure 2-11.

STEP 15: Each impulse capacity Iw, Ip, and Id determined from Steps 12 through 14 must be equal to or greater than the imposed impulse loading determined in Step 11. If any one of these impulse capacities is less than the value of Step 11, then the magazine structure is not adequate to resist the imposed blast loading. Possible solution would be either to increase blast loading. Possible solution would be either to increase the impulse capacity of the magazine by structural modifications or reduce the quantity of stored

explosives to an acceptable quantity as shown in Procedure 2.

2.3 Procedure 2 - Determine Allowable Quantity of Stored Explosive.

STEP 1: From Figure 1-1, select the headwall configuration type that most closely matches the existing magazine. The configuration type will determine the figures to be used in the analysis. For this example, Headwall Configuration Type 1 will be used.

STEP 2: From Figure 2-3, determine the wall impulse capacity (Iw).

STEP 3: From Figure 2-9, determine the door impulse capacity (Id).

STEP 4: Select the smaller of the values from Steps 2 and 3.

STEP 5: Select a value of net explosive weight (W).

STEP 6: For the condition with the donor magazine located to the side of the acceptor magazine, determine the clear distance in feet (R) between the sides of the magazine arches (see Figure 2-1).

STEP 7: Calculate the scaled distance by dividing the distance (R) in Step 6 by the cube root of the net explosive weight (W) determined in Step 5.

STEP 8: Enter Figure 2-1 with the scaled distance $R/W^{1/3}$ from Step 7 and read the value of the scaled incident impulse $Is/W^{1/3}$ from the solid line curve for a confined explosion.

STEP 9: Calculate the incident impulse (Is) by multiplying the scaled incident impulse value from Step 8 by $W^{1/3}$.

STEP 10: If there is no magazine in front of the acceptor magazine, then Steps 10 through 13 will not be necessary. For the condition with the donor magazine located in front of the acceptor magazine, determine the clear distance in feet (R) between the rear wall of the donor magazine and the front (head) wall of the acceptor magazine (see Figure 2-2).

STEP 11: Calculate the scaled distance by dividing the distance (R) in Step 10 by the cube root of the net explosive weight (W) selected in Step 5.

STEP 12: Enter Figure 2-2 with the scaled distance $R/W^{1/3}$ from Step 11 and read the value of the scaled reflected impulse $Ir/W^{1/3}$ from the solid line curve for a confined explosion.

STEP 13: Calculate the reflected impulse (Ir) by multiplying the scaled reflected impulse value from Step 12 by $W^{1/3}$.

STEP 14: Select the larger of the values from Step 9 and Step 13 (only one value from Step 9 will exist if there is no donor magazine in front of the acceptor magazine).

STEP 15: Compare the impulse value determined by Step 4 with that of Step 14. If the value determined by Stem 4 is equal to or larger than the determined in Step 14, then the structure of the acceptor magazine is adequate to resist the blast from the quantity of explosives selected in Step 5. If the value determined by Step 4 is less than that determined by Step 14, then the structure of the acceptor magazine is not adequate for the quantity of explosive selected. Try a lower value of explosive quantity for Step 5 and repeat Steps 6 through 15. (Note: See discussion in paragraph 2.1b(2) concerning allowable quantity of stored explosive in a nonstandard earth-covered magazine).

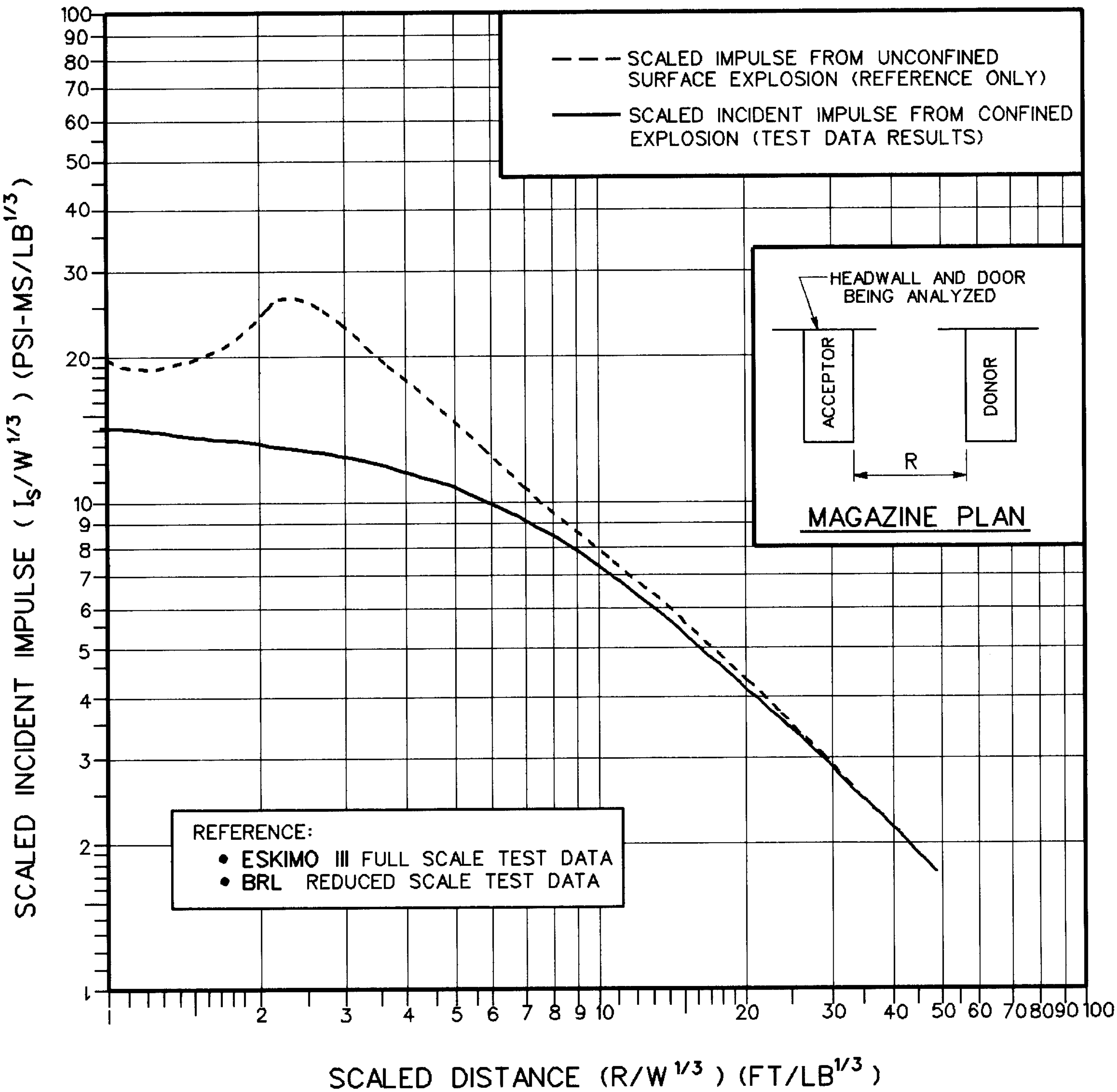


Figure 2-1 Scaled Incident Impulse VS Scaled Distance
(Side To Side)

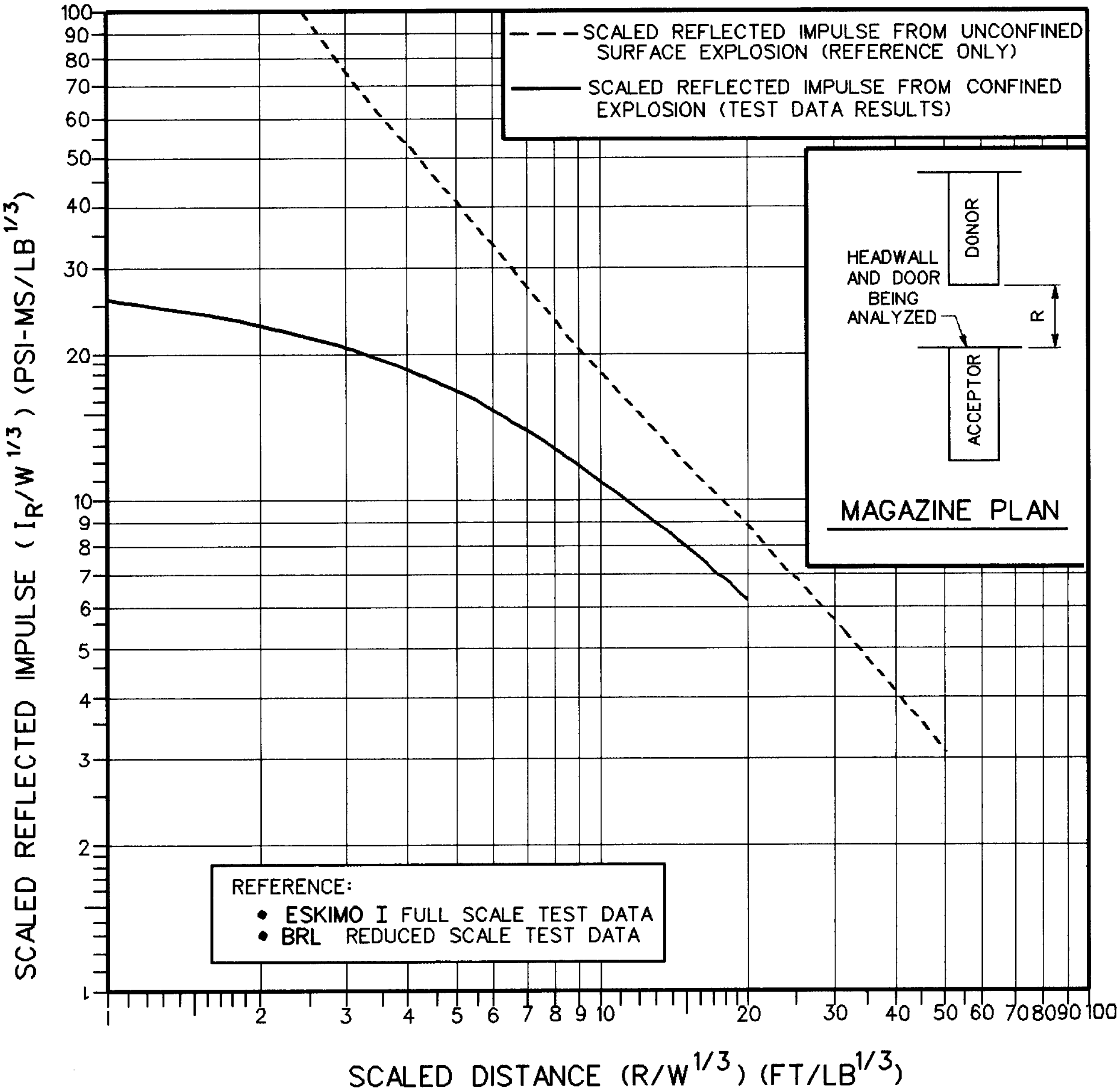


Figure 2-2 Scaled Reflected Impulse VS Scaled Distance
(Rear to Front)

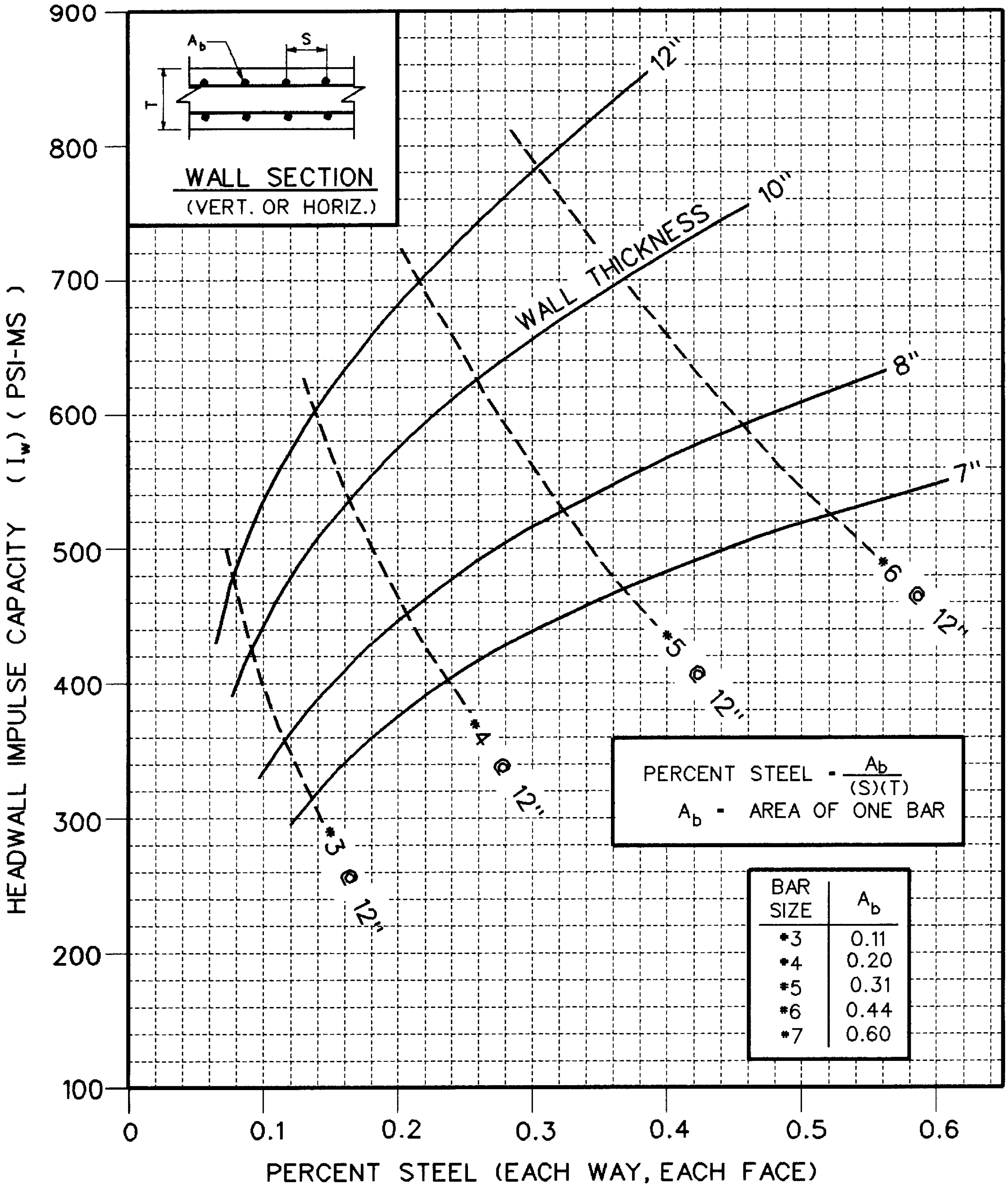
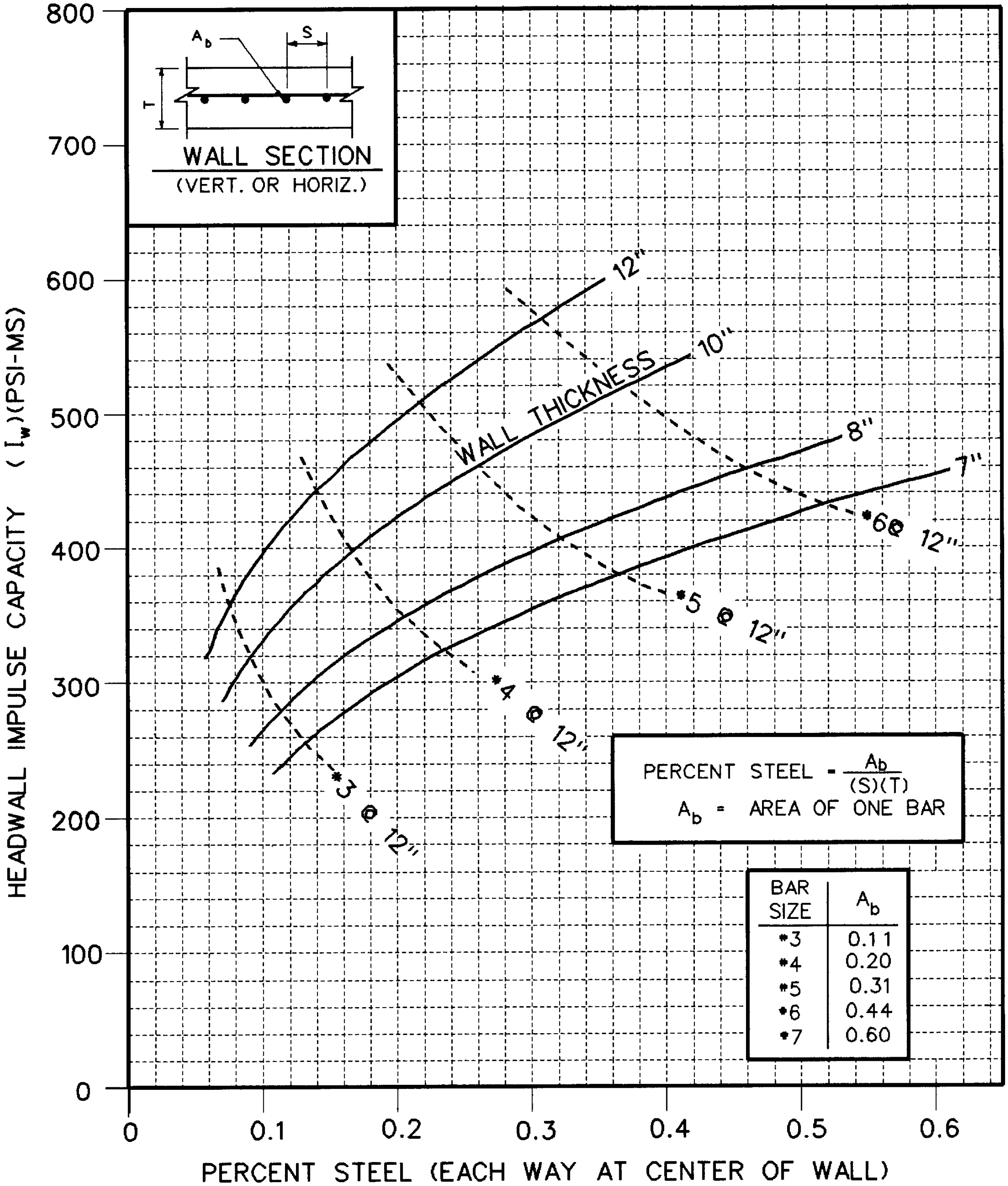


Figure 2-3 Wall Impulse Capacity VS Percent Steel
(With 4.5'x8' Door) (Without Pilasters)



BAR SIZE	A_b
#3	0.11
#4	0.20
#5	0.31
#6	0.44
#7	0.60

Figure 2-4 Wall Impulse Capacity VS Percent Steel
(With 4.5'x8' Door) (Without Pilasters) (Single Steel Layer)

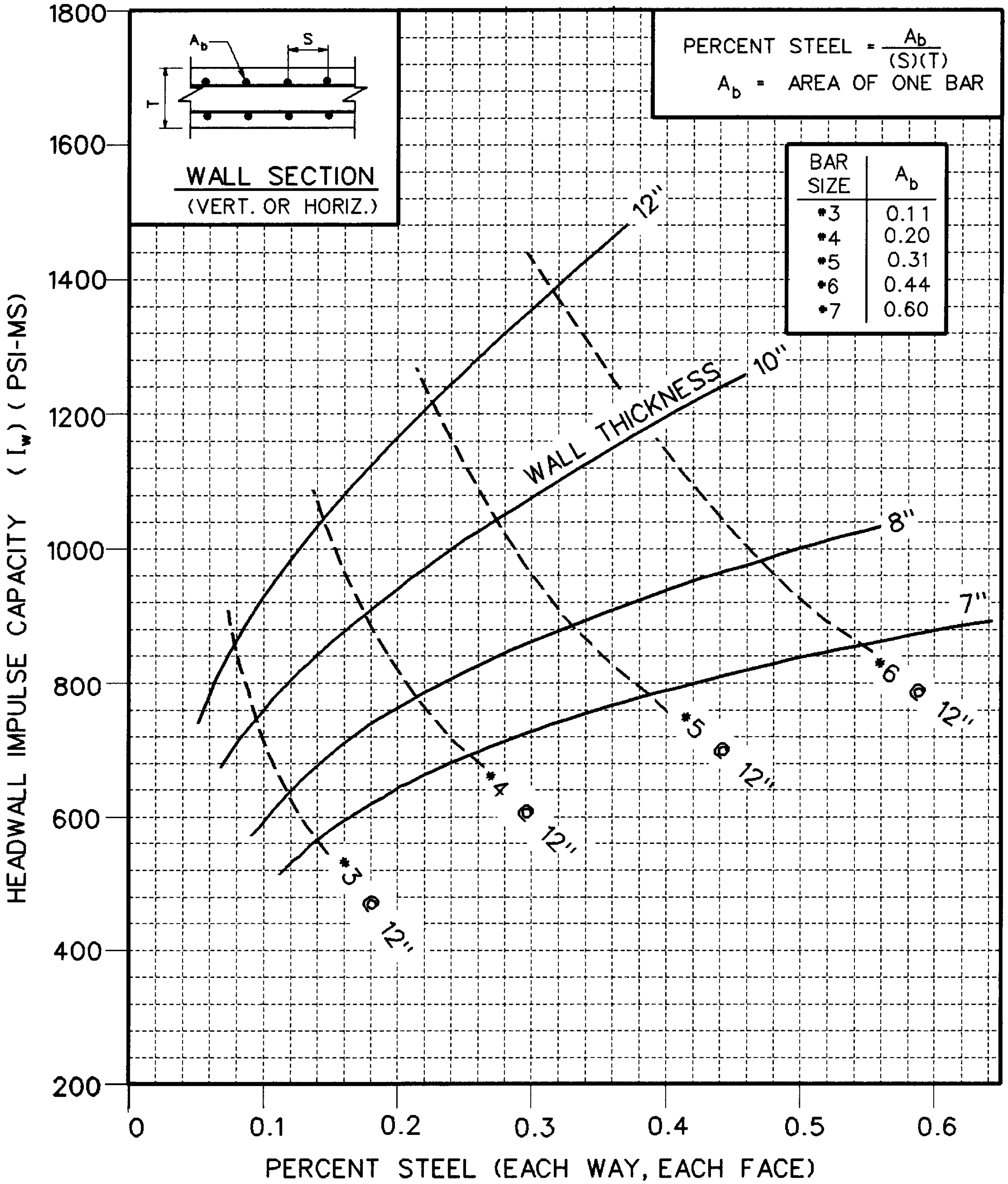


Figure 2-5 Wall Impulse Capacity VS Percent Steel
(With 4.5'x8' Door) (With Pilasters)

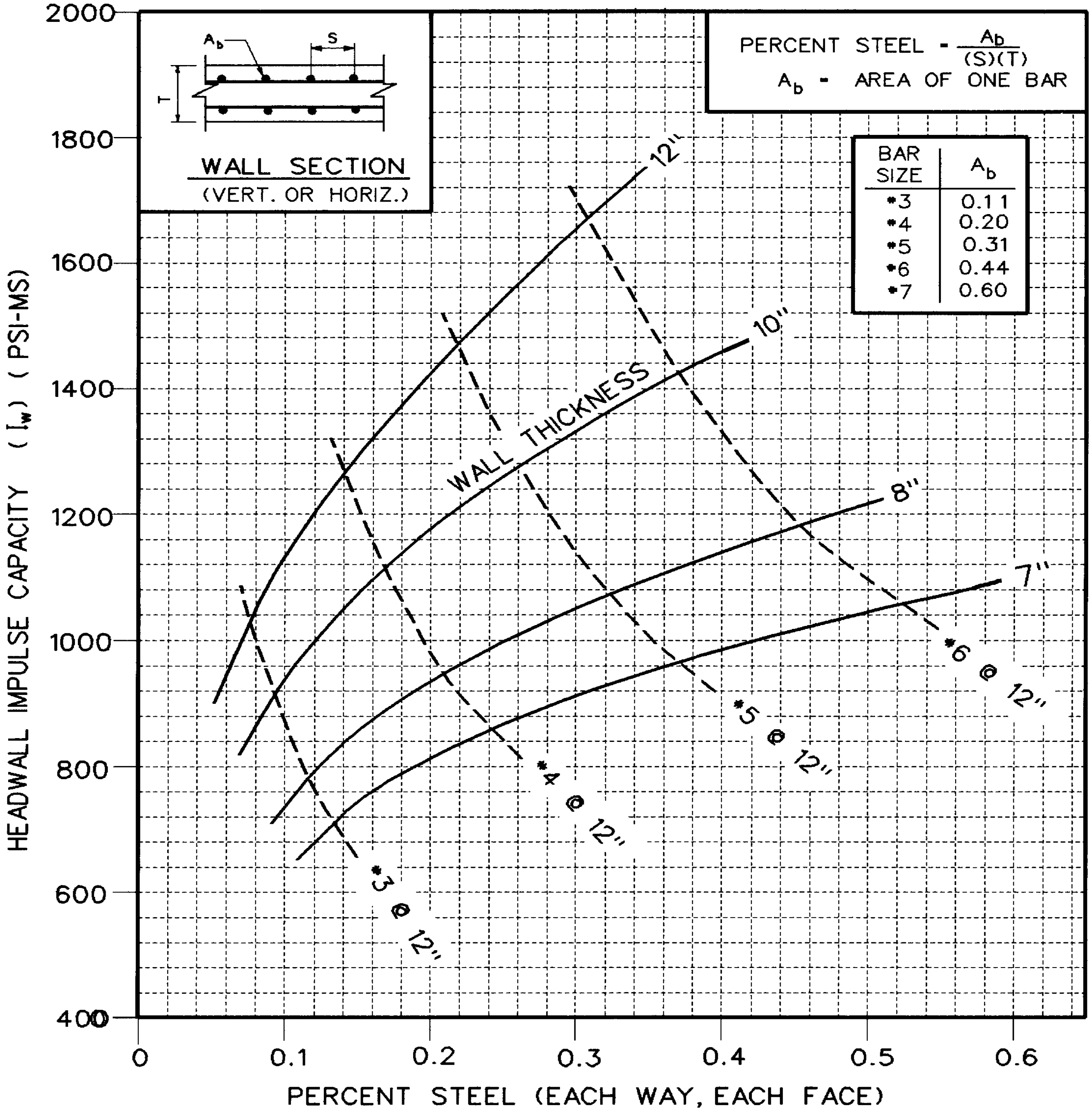


Figure 2-6 Wall Impulse Capacity VS Percent Steel
(With 10'x10' Door) (With Pilasters)

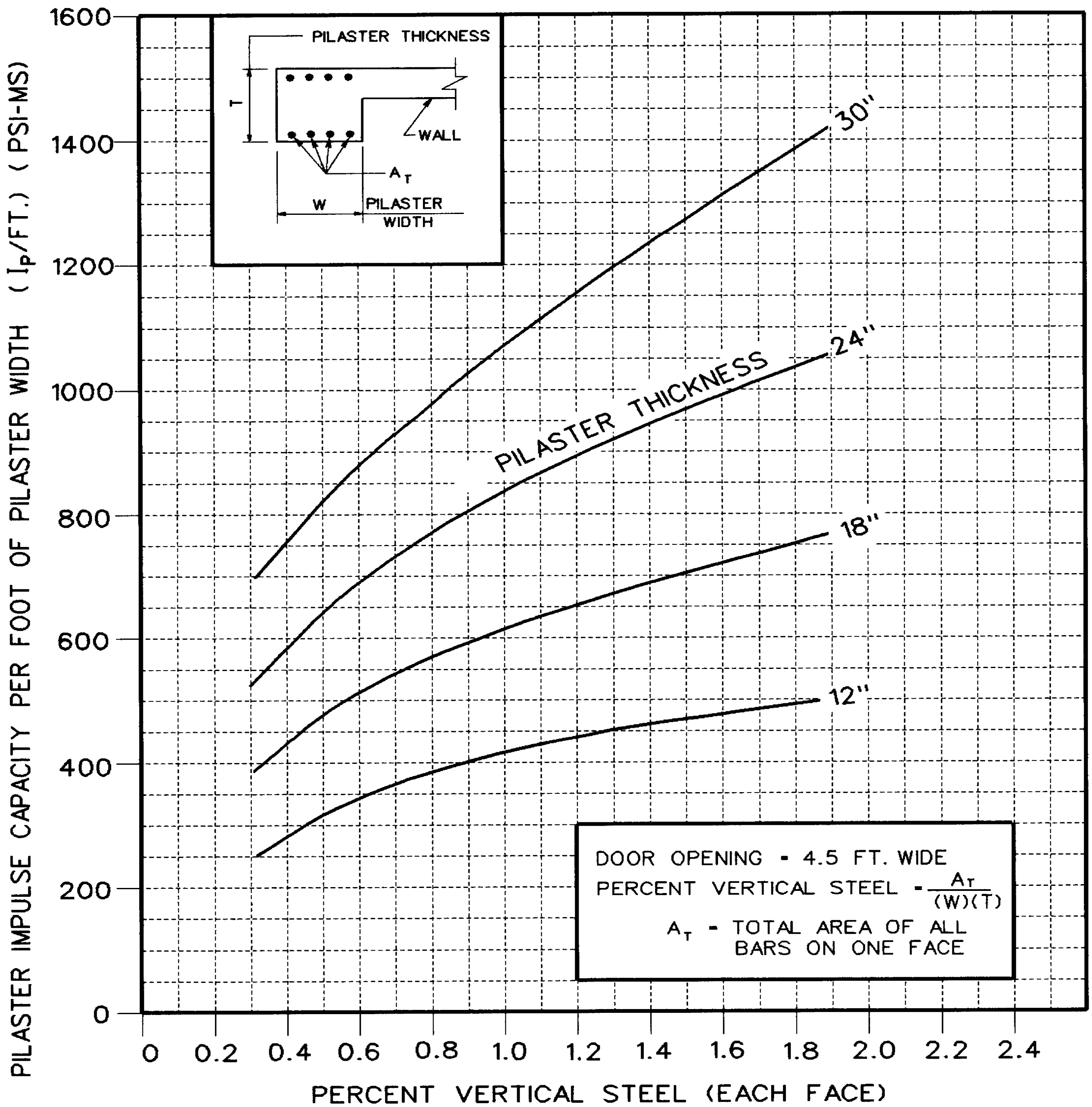


Figure 2-7 Pilaster Impulse Capacity VS Percent Steel
(With 4.5'x8' Door)

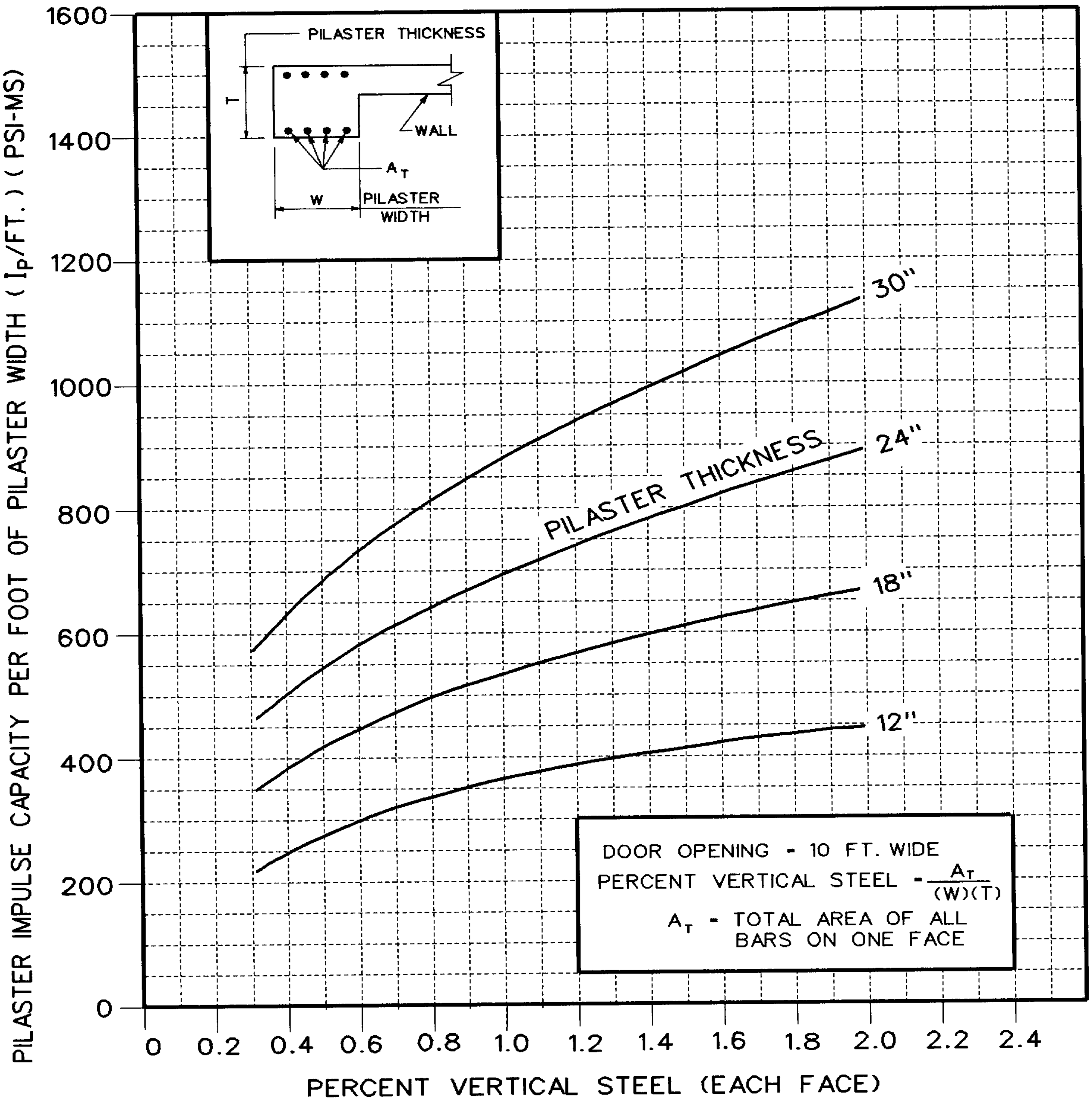


Figure 2-8 Pilaster Impulse Capacity VS Percent Steel
(With 10'x10' Door)

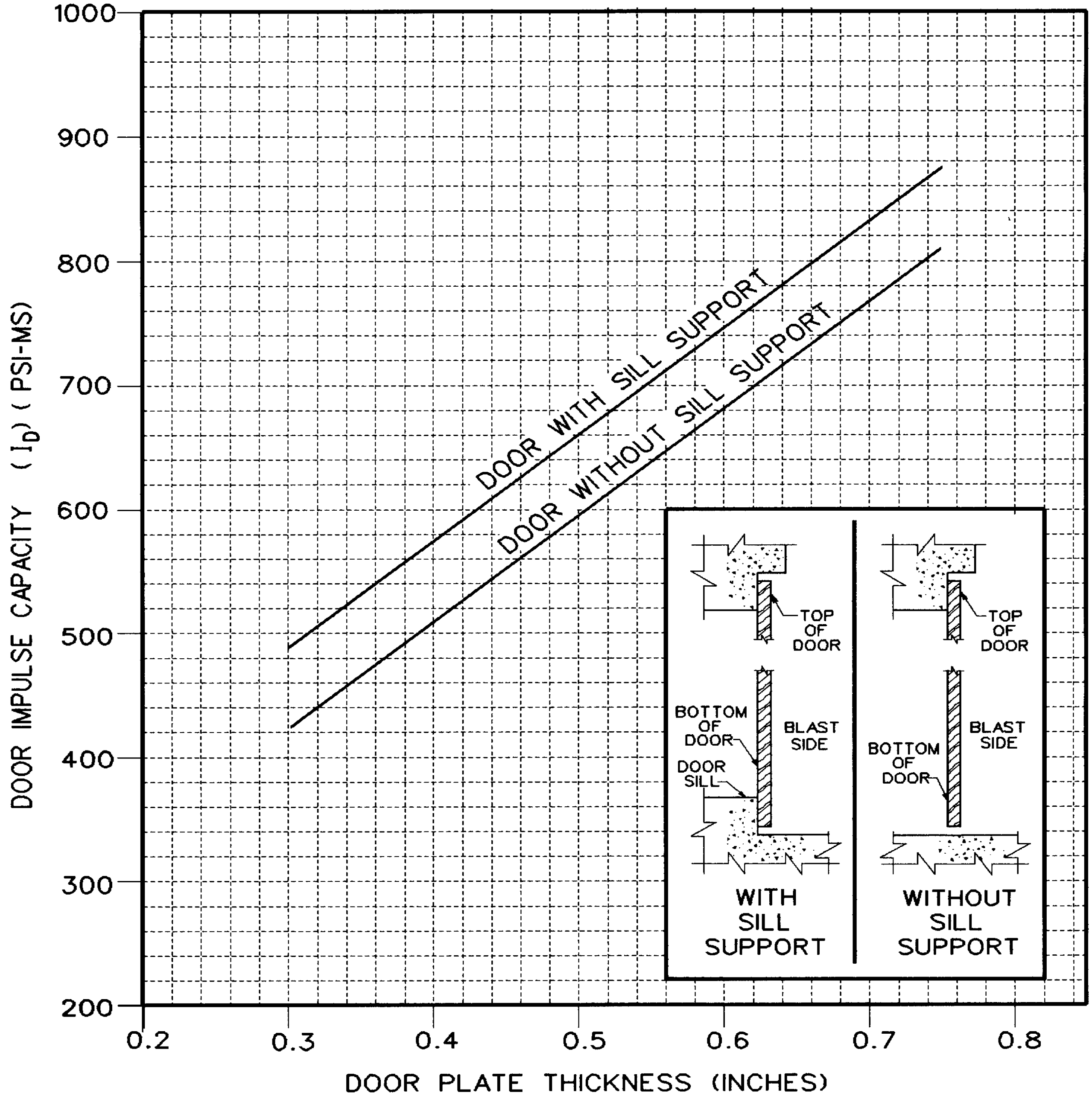


Figure 2-9 Door Impulse Capacity VS Door Plate Thickness
(4.5'x8' Unstiffened Single Leaf Door)

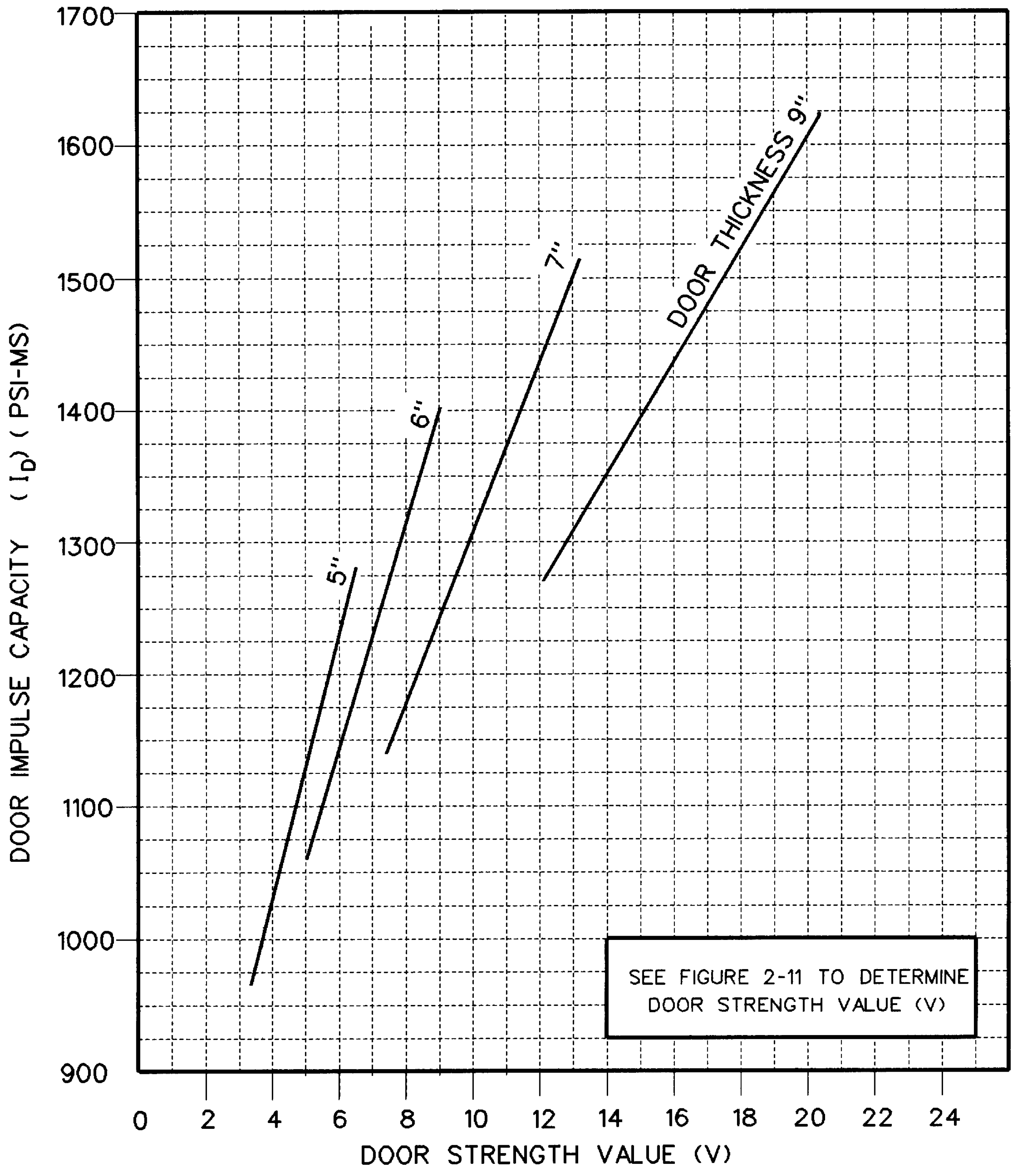


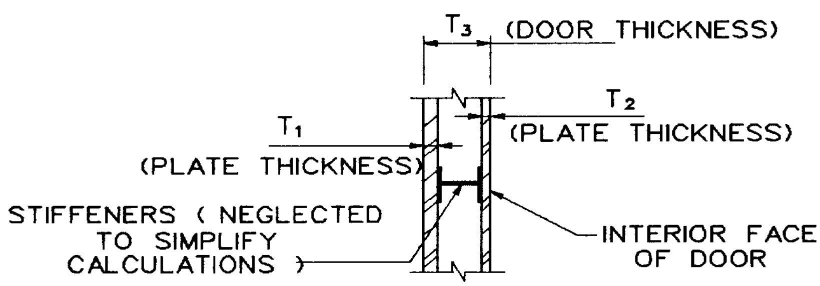
Figure 2-10 Door Impulse Capacity VS Door Strength Value
(10'x10' Stiffened Single Unit Door)

DETERMINE DOOR STRENGTH VALUE (V) FOR FIGURE 2-10 FROM THE FOLLOWING EQUATIONS:

$$V = (T_2)(A)^2 + (T_1)(T_3 - A)^2$$

WHERE:

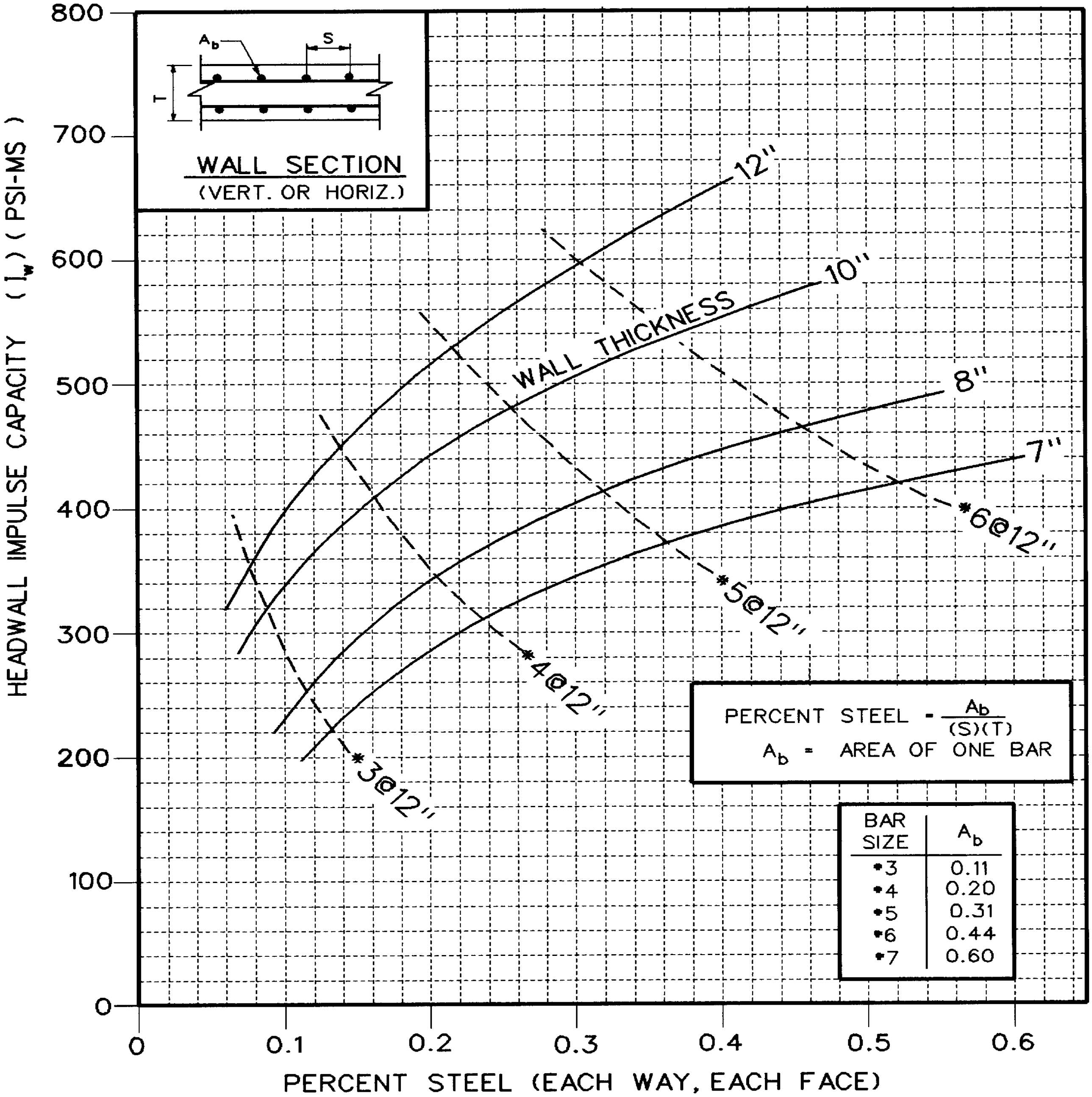
$$A = \frac{(0.5)(T_2)^2 + (T_1)(T_3)}{T_1 + T_2}$$



SECTION THRU DOOR

(DOOR FOR TYPE 4 HEADWALL CONFIGURATION)

Figure 2-11 Equations For Door Strength Value
(Stiffened Doors)



BAR SIZE	A_b
*3	0.11
*4	0.20
*5	0.31
*6	0.44
*7	0.60

Figure 2-12 Wall Impulse Capacity VS Percent Steel
(With 10'x10' Door) (Without Pilasters)

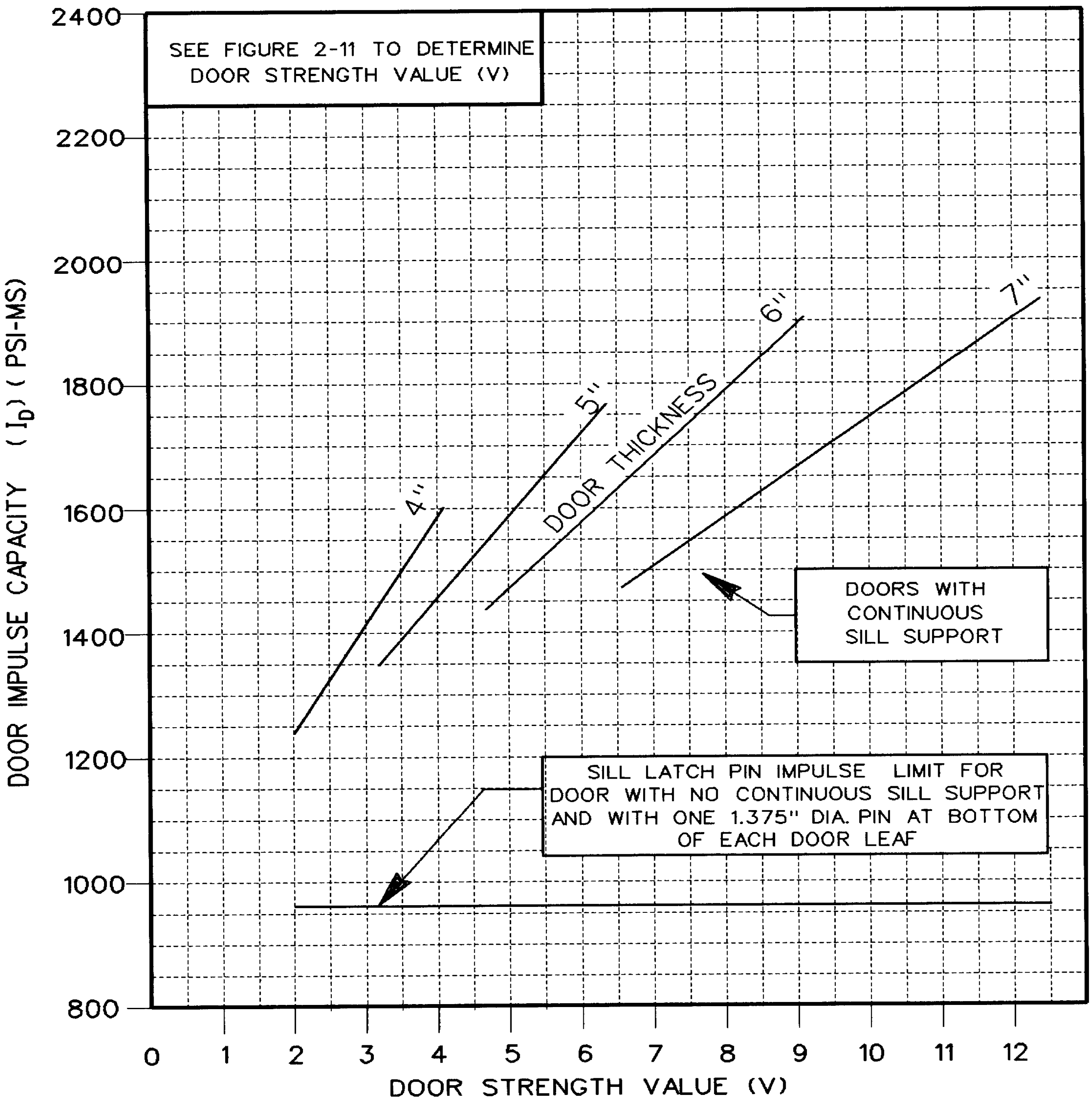


Figure 2-13 Door Impulse Capacity VS Door Strength Value
(10'x10' Stiffened Double Leaf Door)

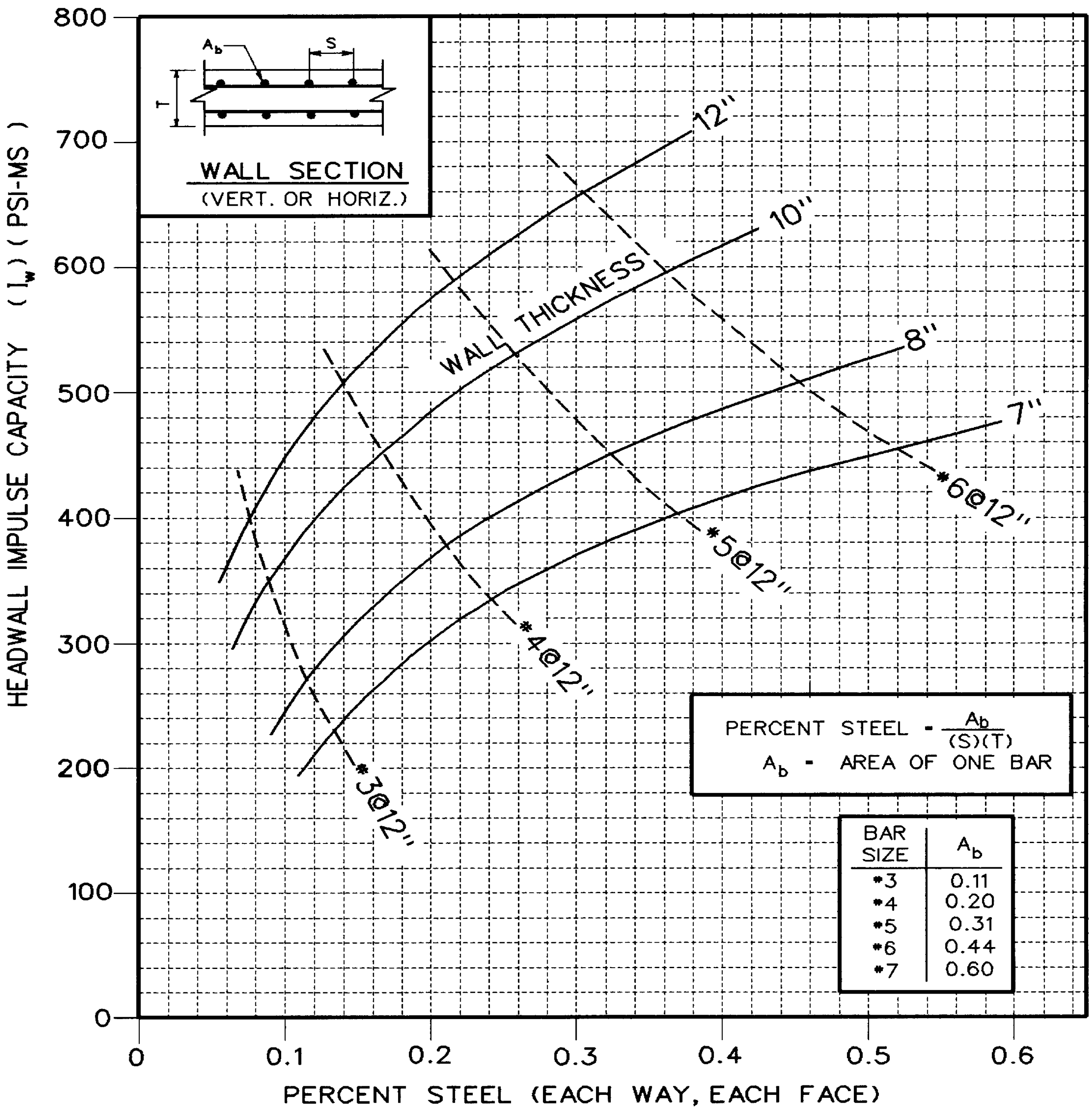


Figure 2-14 Wall Impulse Capacity VS Percent Steel
(With 8'x 8' Door) (Without Pilasters)

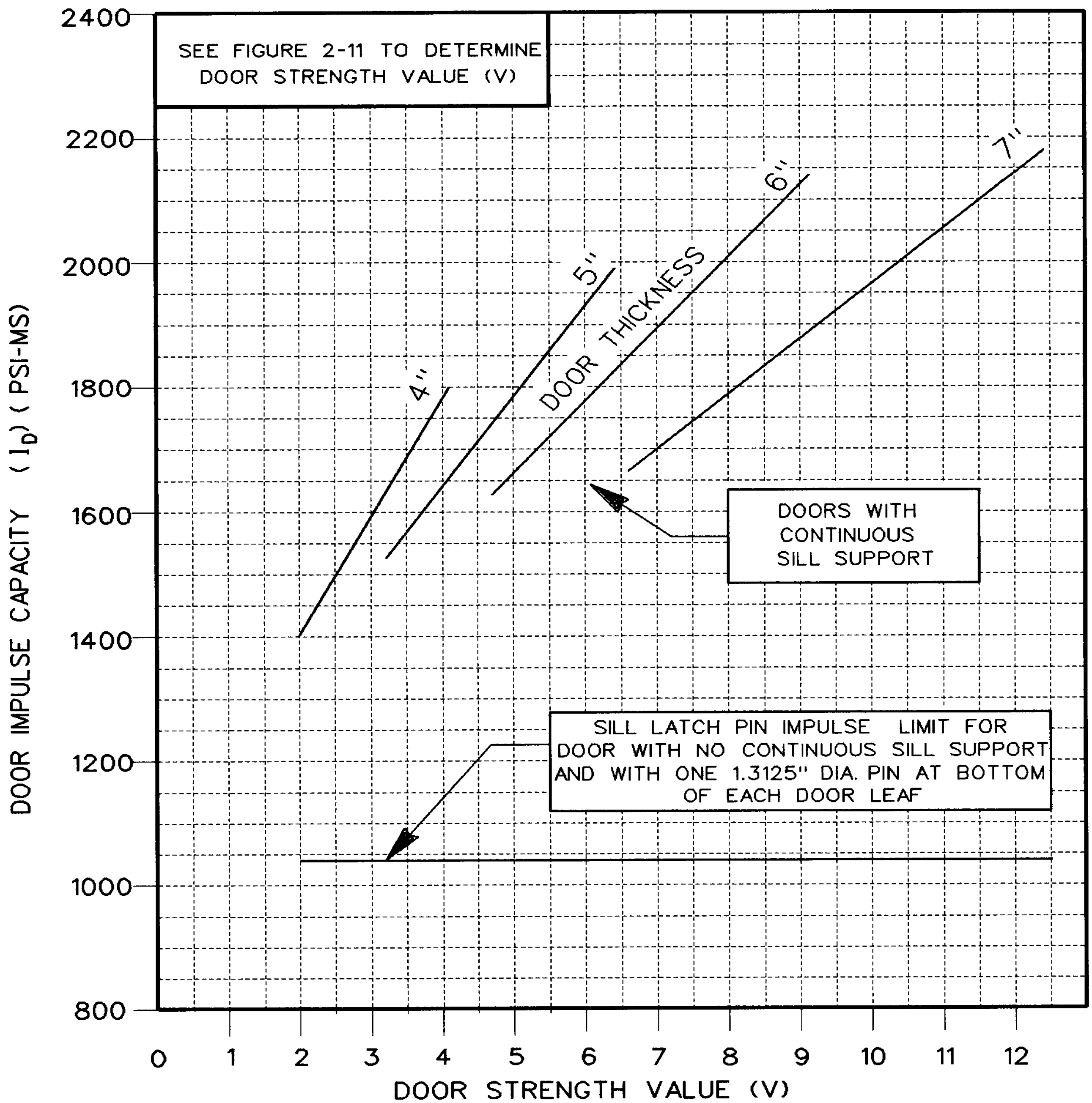


Figure 2-15 Door Impulse Capacity VS Door Strength Value
(8'x 8' Stiffened Double Leaf Door)

3.0 EXAMPLE PROBLEMS

3.1 Example Problem 1.

PROBLEM: Determine the adequacy of a nonstandard magazine to withstand the blast impulse from a quantity of explosives stored in adjacent magazines.

GIVEN:
Net explosive weight = 500,000 LBS
Clear distance between sides of magazine = 100 FT
Donor rear wall to acceptor front wall distance = 475 FT
Headwall Configuration = Type 4
Headwall thickness = 10 IN
Headwall percent steel = 0.258 (#5@12") (E.W., E.F.)
Pilaster width = 1.5 FT
Pilaster thickness = 24 IN
Pilaster percent vertical steel = 1.5
Door thicknesses:
T_1 = 0.375 IN (exterior plate)
T_2 = 0.250 IN (interior plate)
T_3 = 5.0 IN (door thickness)

SOLUTION: Use Procedure 1

STEP 1: From Figure 1-1, select Type 4 Headwall Configuration.

STEP 2: W = 500,000 LBS

STEP 3: R = 100 FT

STEP 4: $R/W^{1/3} = 100/(500{,}000)^{1/3} = 1.26$

STEP 5: From Figure 2-1 with a scaled distance of 1.26, read a value of 13.75 for the scaled incident impulse.

STEP 6: $Is = (13.75)(500{,}000)^{1/3} = 1090$ PSI-MS

STEP 7: R = 475 FT

STEP 8: $R/W^{1/3} = 475/(500{,}000)^{1/3} = 5.98$

STEP 9: From Figure 2-2 with a scaled distance of 5.98, read a value of 14.5 for the scaled reflected impulse.

STEP 10: $Ir = (14.5)(500,000)^{1/3} = 1151$ PSI-MS

STEP 11: Select the larger of the values from Steps 6 and 10. Use 1151 PSI-MS.

STEP 12: From Figure 2-6 with a percent steel of 0.258 (#5@12") and a wall thickness of 10 inches, read 1280 PSI-MS for the wall impulse capacity. Since 1280 PSI-MS is larger than 1151 PSI-MS value of Step 11, then the wall element is adequate for blast loading.

STEP 13: From Figure 2-8 with a percent vertical steel of 1.5, and a pilaster thickness of 24 inches, read 800 PSI-MS for the pilaster impulse capacity per foot of pilaster width. Multiply this value by the pilaster width of 1.5 feet to obtain a total pilaster impulse capacity of 1200 PSI-MS. Since 1200 PSI-MS is larger than the 1151 PSI-MS value of Step 11, then the pilaster is adequate for the blast loading.

STEP 14: From Figure 2-11 with $T_1 = 0.375"$, $T_2 = 0.250"$ and $T_3 = 5$ calculate $V = 3.75$. Then from Figure 2-10 with $V = 3.75$ and a 5-inch thick door read 1010 PSI-MS for the door impulse capacity. Since 1010 PSI-MS is less than the 1151 PSI-MS value of Step 11, then the door is not adequate for the blast loading. Possible solution would be either to increase the door capacity or reduce the amount of explosive stored in the adjacent magazine. To increase the door capacity would involve an engineering redesign of the door using structural analyses methods given in TM 5-1300.

3.2 Example Problem 2.

PROBLEM: Determine the amount of explosives that may be stored in adjacent donor magazines without creating a blast propagation hazard to a nonstandard acceptor magazine.

GIVEN:
Clear distance between sides of magazine = 100 FT
Donor rear wall to acceptor front wall distance=475FT
Headwall configuration = Type 1
Headwall thickness = 10 IN
Percent steel in headwall face = 0.258 (#5@12")
(E.W., E.F.)
Door size = 4.5 FT wide
Door plate thickness = 0.625 IN
Door has sill support

SOLUTION: Use Procedure 2

STEP 1: From Figure 1-1, select Type 1 Headwall Configuration.

STEP 2: From Figure 2-3 with a percent steel of 0.258 and a 10-inch wall thickness, read 625 PSI-MS for the wall impulse capacity.

STEP 3: From Figure 2-9 for a 4.5 FT wide X 0.625 IN thick door supported on all four sides, read 770 PSI-MS for the door impulse capacity.

STEP 4: Select the smaller of the values from Steps 2 and 3. Use 625 PSI-MS.

STEP 5: Select a value of 500,000 LBS for the net explosive weight.

STEP 6: R = 100 FT

STEP 7: $R/W^{1/3} = 100/(500{,}000)^{1/3} = 1.26$

STEP 8: From Figure 2-1 with a scaled distance of 1.26, read a value of 13.75 for the scaled incident impulse.

STEP 9: $Is = (13.75)(500{,}000)^{1/3} = 1090$ PSI-MS

STEP 10: R = 475 FT

STEP 11: $R/W^{1/3} = 475/(500{,}000)^{1/3} = 5.98$

STEP 12: From Figure 2-2 with a scaled distance of 5.98, read a value of 14.5 for the scaled reflected impulse.

STEP 13: $Ir = (14.5)(500{,}000)^{1/3} = 1151$ PSI-MS

STEP 14: Select the larger of the values from Steps 9 and 13. Use 1151 PSI-MS

STEP 15: Since the impulse capacity (625 PSI-MS) determined by Step 4 is less than the impulse loading (1151 PSI-MS) determined by Step 14, then the acceptor magazine is not adequate to resist the blast loading form the 500,000 LBS of explosives. Repeat Steps 5 through 15 with a lower quantity of net explosive weight.

STEP 16: Try a value of 250,000 LBS for the net explosive weight. (NOTE: See discussion in paragraph 2.1b(2) concerning allowable quantity of stored explosive in a nonstandard earth-covered magazine.)

STEP 17: R = 100 FT

STEP 18: $R/W^{1/3} = 100/(250{,}000)^{1/3} = 1.59$

STEP 19: From Figure 2-1 with a scaled distance of 1.59, read a value of 13.5 for the scaled incident impulse.

STEP 20: $Is = (13.5)(250{,}000)^{1/3} = 850$ PSI-MS

STEP 21: R = 475 FT

STEP 22: $R/W^{1/3} = 475/(250,000)^{1/3} = 7.54$

STEP 23: From Figure 2-2 with a scaled distance of 7.54, read a value of 13.4 for the scaled reflected impulse.

STEP 24: $Ir = (13.4)(250,000)^{1/3} = 844$ PSI-MS

STEP 25: Select the larger of the values from Steps 20 and 24. Use 850 PSI-MS

STEP 26: Since the impulse capacity (625 PSI-MS) determined by Step 4 is still less than the impulse loading (850 PSI-MS), the theoretically acceptable quantity of store explosive is some value less than 250,000 pounds. However, since paragraph B.2, Chapter 5 of DOD 6055.9-STD allows up to 250,000 pounds of explosive to be stored, then this should be the value used for the maximum amount of stored explosive.